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ISBN 0-7729-2573-9

STANDARDS DEVELOPMENT BRANCH OMOE
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AIR MONITORING REPORT
ON THE
CANADA METAL COMPANY LIMITED

SEPTEMBER 1987

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Ministry
of the
Environment
Ontario

G. MIERZYNSKI, Director
Central Region

AIR MONITORING REPORT
ON
THE CANADA METAL COMPANY LIMITED

STANDARDS DEVELOPMENT BRANCH
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SEPTEMBER 1987

ISBN NO. 0-7729-2573-9

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1.0 EXECUTIVE SUMMARY

An extensive air monitoring network around Canada Metal has been in operation since the early 1970's in order to monitor lead emissions from the lead processing plant. The declining trend of airborne lead levels reflects the effects of major abatement programs and the drastic reduction in automotive lead emissions.

A 66% drop in particulate lead concentration was recorded at the residential sampling site 31064 (∿50 metres N.of plant) between the year 1974 and 1986. Similarly a 76% decline was observed at the industrial station 31058 (∿15 metres NE/E of plant). Statistical tests indicated that the lead levels detected at the residential site were significantly lower than those at the industrial location.

Wind correlation analyses showed that Canada Metal continued to be the principal source of lead. Although there was a dramatic decrease in air lead emissions, occasional exceedances of the Ambient Air Quality Criteria were observed.

Since lead remains to be one of the major air toxics, it is recommended that the surveillance of the Company be continued.

1.0 RÉSUMÉ

Un réseau étendu de surveillance de la qualité de l'air a été mis en place aux environs de Canada Metal au début des années 1970 afin d'étudier le plomb contenu dans les émanations de l'usine de traitement. L'application des programmes de dépollution et l'importante réduction des émanations de plomb des véhicules automobiles ont entraîné une baisse générale de la concentration de plomb dans l'air.

De 1974 à 1986, on a noté une baisse de 66 pour 100 de la concentration de particules de plomb dans les échantillons prélevés à l'emplacement n° 31064 en zone résidentielle (situé à environ 50 mètres au nord de l'usine). On a également noté une baisse de 76 pour 100 dans les échantillons prélevés à l'emplacement n° 31058 en zone industrielle (situé à environ 15 mètres au NE/E de l'usine). Les analyses statistiques ont indiqué que les concentrations de plomb relevées en zone résidentielle étaient beaucoup plus faibles que celles relevées en zone industrielle.

Les analyses de corrélation du vent démontrent que Canada Metal est toujours la principale source d'émanations de plomb. Malgré une importante réduction de ces émanations, les limites en matière de qualité de l'air ambiant ont parfois été dépassées.

Le plomb étant un des principaux polluants atmosphériques, on recommande de poursuivre la surveillance de la qualité de l'air aux environs de l'usine.

2.0 INTRODUCTION

In the early seventies, an extensive air monitoring network was established in the vicinity of The Canada Metal Company Limited. Its purpose was to monitor airborne lead levels around the lead processing plant.

During the same period, the Working Group On Lead was set up by the Ministry as a focal point of the efforts of people working directly on the problems of lead contamination in the Toronto area. The general objectives were to assess the lead data collected, to determine the effect of these lead levels on public health, and to recommend actions to be taken by the Ministry. [2]

After reviewing the data on lead levels in the air, dustfall, soil, and vegetation near the five lead processing plants (Canada Metal was one), the Working Group found that the operations of these plants had contributed to lead contamination in excess to those found in urban areas due to other industrial and automobile sources. One of the recommendations of the Group was to continue the monitoring of lead levels in the vicinity of lead sources. [2]

The purpose of this report is to present the air monitoring data from the Canada Metal survey. Lead in soil and vegetation and other issues are beyond the scope of this report.

3.0 THE CANADA METAL COMPANY LIMITED

The Canada Metal Co. Ltd. is located at 721 Eastern Avenue, in the east end of the City of Toronto. It is situated in the area of South Riverdale which is bounded by the Lakeshore Blvd. E. to the south, the Don Valley Parkway to the west, Gerrard St. E. to the north, and Coxwell Avenue to the east.

The area south of Eastern Ave. has a mix of heavy industries. To the north of the plant, it is a light to moderate residential area between Eastern Ave. and Queen St. E. There is an additional mix of industries and residences between Queen St. and Gerrard St., particularly near the C.N.R. railway track.

The company manufactures lead and lead alloys for solder, lead oxide for use in batteries and as paint and ink pigments. The lead is derived from the melting of lead battery plates and other forms of lead oxide in a blast furnace. The lead oxide is produced by melting lead in a pot furnace and subsequently converting this molten lead chemically into lead oxides in oxidizing furnaces.[2]

Dust and fume emissions can be generated from the smelting, refining, alloying, casting, and lead oxide operations. Baghouses are in place throughout the processes to minimize environmental contaminations.

Major abatement actions were imposed on the company in 1974, 1976, and 1979. Such actions, along with the reduction in leaded gasoline emissions, have been mostly responsible for the drastic decrease of airborne lead levels in the vicinity of the plant.

4.0 LEAD IN AIR

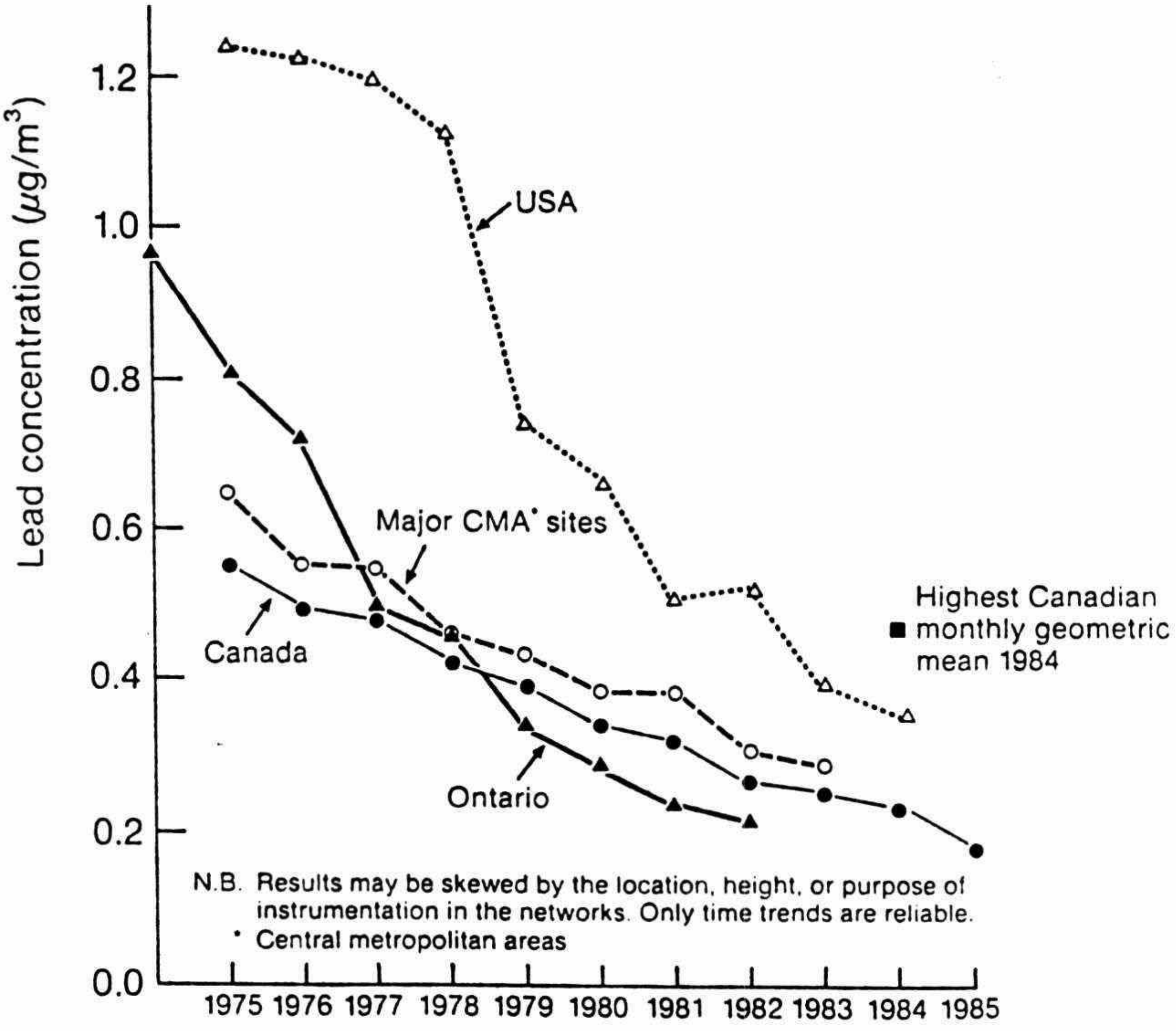
The emissions of lead into the environment are of great importance. The lead in air concentrations may influence human exposure through direct inhalation of lead-containing particles and through ingestion of lead that has been deposited onto surfaces.

Particle size distribution is another important consideration. Most airborne lead is associated with particles ranging between 0.1 and 5.0 microns in diameter, with a mean of 0.25 micron in urban air. Although larger and heavier particles settle out within a short distance from the source, smaller particles remain airborne and may be carried great distances depending on meteorological conditions. Size and shape also determine the deposition, retention, and absorption of lead particles in the human lung. [9]

The ambient airborne lead concentrations since 1975 for Ontario are compared with those for Canada, the United States, and Central Metropolitan Areas (CMA) in Figure 1. [5] The monthly maximum of 0.65 $\mu g/m^3$ recorded at one of the NAPS (National Air Pollution Surveillance) network stations is also plotted. The trend shows a clear decline in airborne lead levels throughout the period.

The majority of the lead compounds in air result from leaded gasoline combustion. Approximately 90% of the total atmospheric lead in the United States was contributed by transportation sources.[8] However, the extensive use of lead additives in gasoline has decreased drastically over the years as seen in Figure 2.

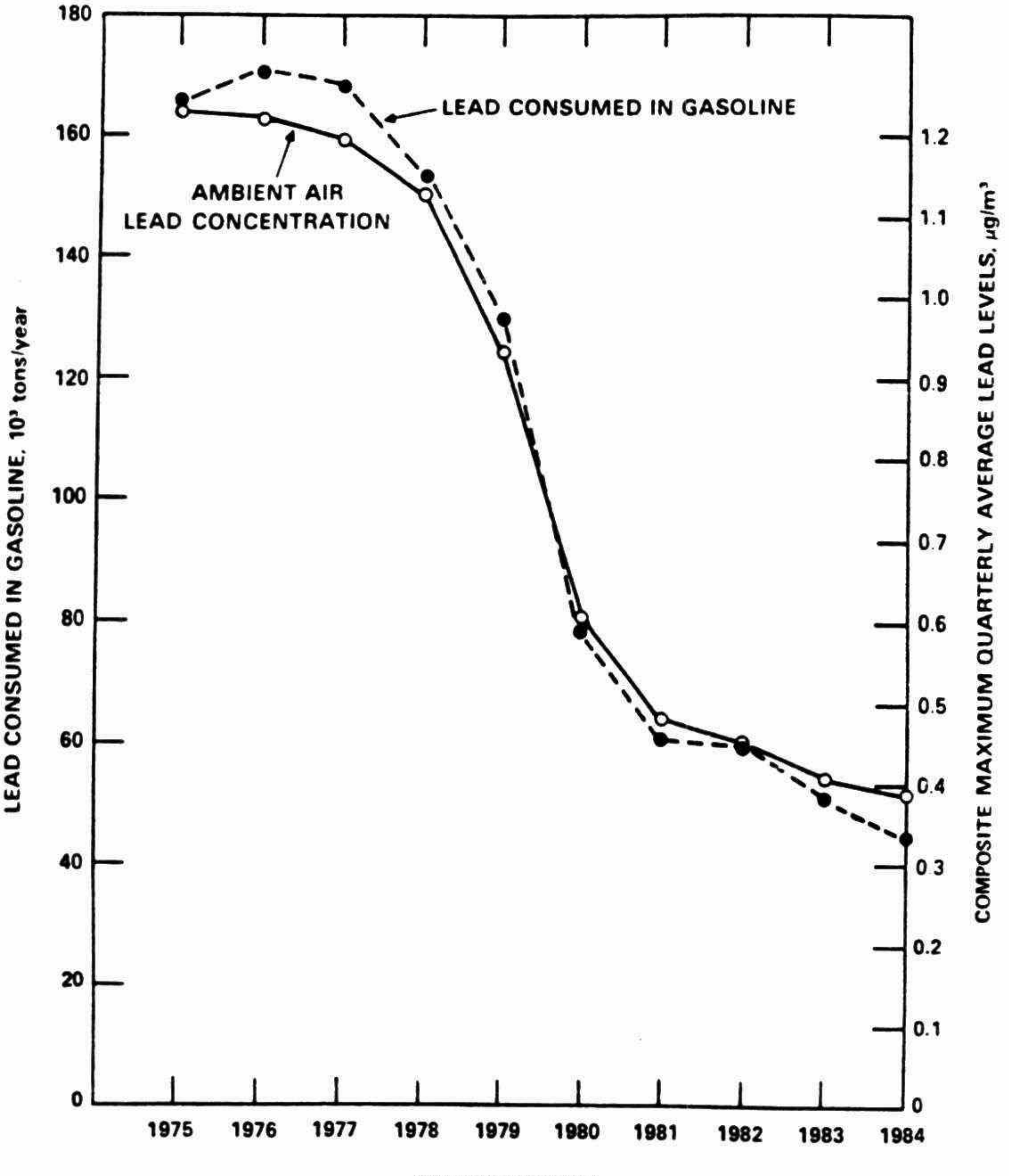
FIGURE 1
TRENDS IN ANNUAL GEOMETRIC MEAN LEAD IN AIR CONCENTRATIONS



Source: EPA 1984; MOE 1984; EPS 1985a,b

FIGURE 2
LEAD CONSUMED IN GASOLINE AND AMBIENT LEAD CONCENTRAIONS
1975 - 1984

(U.S. DATA)



Source: US EPA 1985, 1986.

Also presented in Figure 2 were average ambient lead levels over the years. The lead consumed in gasoline decreased 73% during the period 1975-1984; while the corresponding composite maximum quarterly average of ambient lead decreased 71% (from 1.23 to 0.36 μg/m³).[8]

Although the decline of leaded gasoline consumption must have had a great impact on the reduction of airborne lead levels, it is quite clear from the comparison of Canada, the U.S., and the U.K. shown in Table 1[5] that this was not the only factor responsible for the reduction.

TABLE 1

ATMOSPHERIC LEAD REDUCTION

Location	Time Period	% Reduction In Lead Usage (in gasoline)	% Reduction In Atmospheric Lead
Canada	1970 - 1982	54	74
U.S.	1975 - 1980	53	52
U.K.	1972 - 1982	9	50

* Time Periods vary to match source data.

Sources: Southwood, 1983;
EPA, 1986a;
EPS, 1985a;
Pace, 1985

4.1 SOURCES AND PATHWAYS

Lead is a naturally occurring element and has a remarkable number of good properties. It has been used extensively for thousands of years. Lead also has bad properties which have been recognized for centuries. It is a poison which, if absorbed in sufficient quantity, can produce illness and even death in humans and in other forms of life. [4]

Lead may be found in water, soil, plants, animals and humans. Particularly important are the emissions of lead into the atmosphere. The sources of these emissions and their pathways through the environment to man are shown in Figure 3. [8]

The diagram shows inputs by natural deposition as well as transportation and industrial sources. From these sources, lead moves through the different modules of the human environment. It may be subsequently be deposited on soil, plants and in animals, thus being incorporated into the human food chain. Atmospheric lead is also a major component of household and street dust. [8]

4.2 AIR QUALITY CRITERIA/GUIDELINES

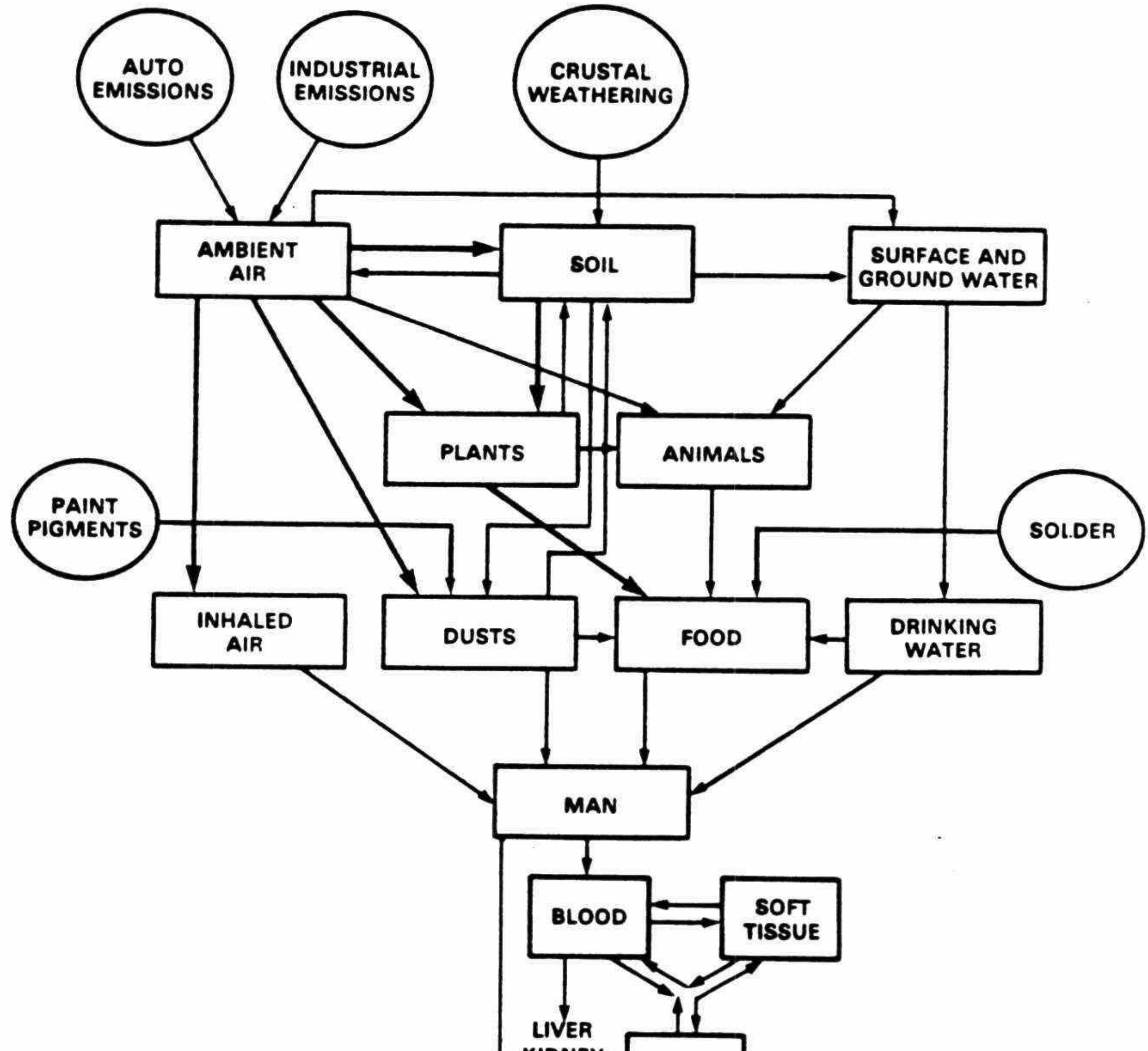
Air quality criteria and other objectives for lead are based on preventing adverse health effects due to lead exposure in the general population.

In late 1972, as new data on the relationship of low level lead exposure and human health became available, the Ministry proposed and later established a new air quality criterion of 5 $\mu g/m^3$ (24 hours), with an accompanying design standard of 10 $\mu g/m^3$ (30 minutes). The bases for the 5 $\mu g/m^3$ criterion were: [2]

FIGURE 3

PATHWAYS OF LEAD FROM THE ENVIRONMENT TO MAN

(MAIN COMPARTMENTS INVOLVED IN PARTITIONING OF INTERNAL BODY BURDEN OF ABSORBED/RETAINED LEAD AND MAIN ROUTES OF LEAD EXCRETION)



1. Assumption of 300 μg lead intake from diet (10% absorption);
2. Assumption of respiration of 20 m^3/day of air (30% absorption); and
3. Limiting total daily intake of lead to less than 60 μg/day.

Also in recognition of the long term effects of low level exposure an additional criterion of 2 μg/m^3 (30 days geometric mean) was proposed and later established.

There is no criteria for lead in dustfall. However, in recognition of the desire to limit lead contamination of soil and dust with resultant availability for inadvertent ingestion by human, particularly children; as well as fugitive dust emissions associated with secondary lead smelters, the Ministry has established a desirable guideline of 0.1 gm/m^2/30 days. This guideline is to be used as a measure of the acceptability of lead in dustfall in an area but not as standard or related to a standard in any way. The bases for the guideline were: [2]

1. Limiting soil contamination rates to the point that it will require at least 20 years to exceed the maximum desirable level of 600 ppm (currently under review) starting with soil at 300 ppm lead;
2. Limiting more than a 3-fold increase above normal urban levels of lead in dustfall; and
3. Limiting the lead content of dustfall to less than 2% by weight.

5.0 AIR MONITORING PROGRAM

In the early seventies, an air monitoring program was initiated for Canada Metal Company Limited. Its purpose was to determine whether lead emissions from the plant were in compliance with Ministry's standards.

5.1 AIR MONITORING NETWORK

The most important factor in the design of an air monitoring network is the careful definition of objectives which can assist in making the necessary design and siting decisions. [7] The purpose of this network was to monitor airborne lead emissions from the lead processing plant; that is, the survey was intended for source-specific purposes.

The network has been continuous and has evolved to meet changing program needs. Two types of instruments were used, the high-volume sampler (hi-vol) and dustfall jar. An anemometer was also in place to provide continuous wind data.

The location of the air monitoring stations has been selected according to siting criteria. The following guidelines [10] were followed:

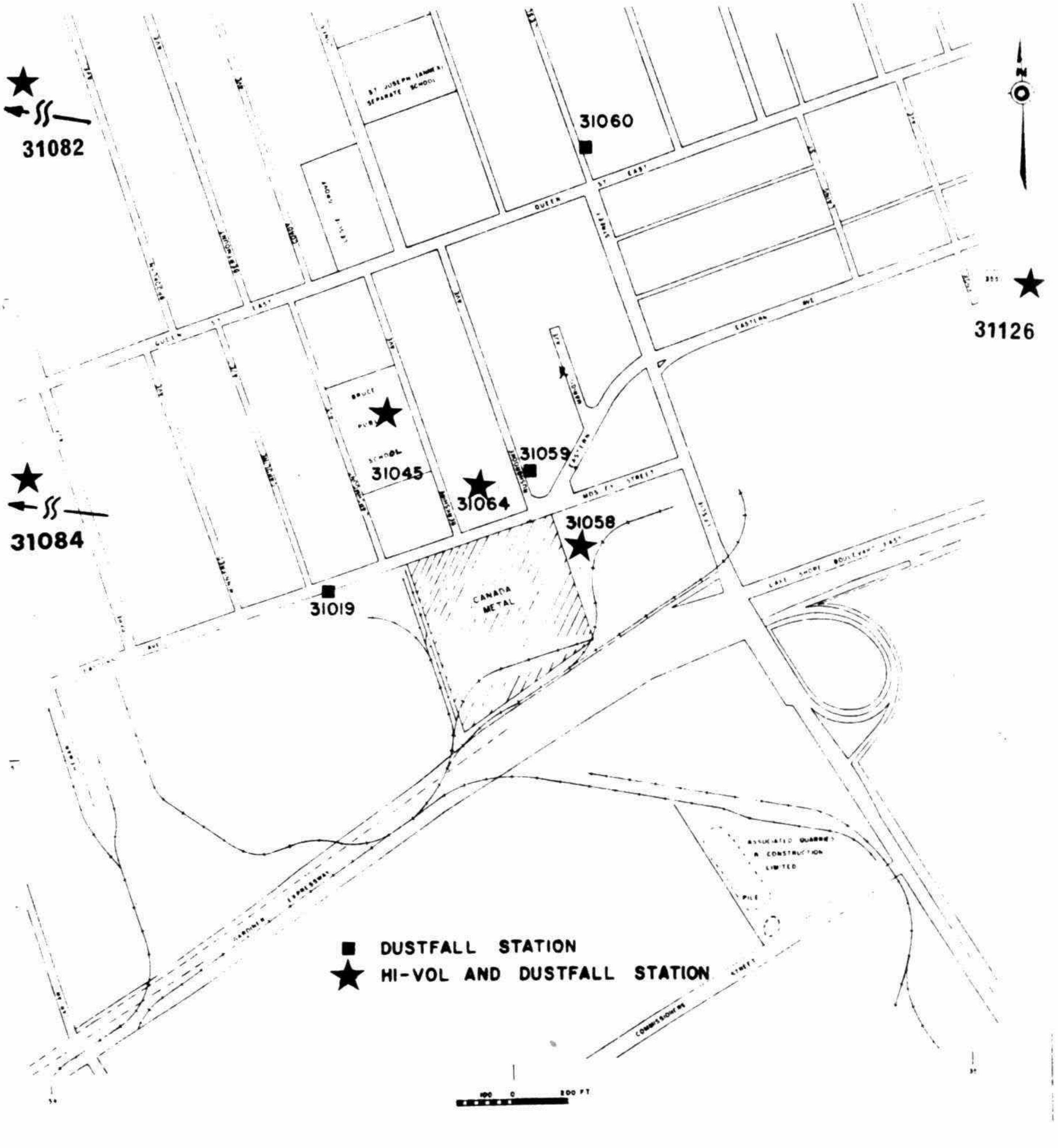
- ** 2-15 m above ground;
- ** at least 2m away horizontally from supporting structures or walls;
- ** should be 20 m from trees;
- ** no obstruction to air flow at least in the direction of prevailing wind.

The description of the current network is summarized in TABLE 2 and the location of the stations is shown in FIGURE 4.

TABLE 2
AIR MONITORING STATION DESCRIPTION

STATION NO.	LOCATION	MONITOR TYPE			HEIGHT ABOVE GROUND, m	COMMENTS
		Hi-vol	Dustfall	Wind		
31019	661 Eastern Ave.		X		5	On Hydro pole, approx. west of plant.
31045	Bruce P.S.-Larchmount Ave	X	X	X	6 23 (wind)	Air monitors on lower roof; Approx. north of plant.
31058	Linkbelt-Moseley/Leslie	X	X		5	Approx. NE/E & close proximity to plant.
31059	Rushbrooke/Eastern		X		4	On Hydro pole, approx. NE of plant.
31060	Leslie/Queen		X		4	On Hydro pole; approx. further NE of plant.
31064	17 Berkshire-backyard	X	X		1	Closest residence-relocated to 31045 in 1986.
31065	A.R. Clarke	X	X		12	Tannery west of plant; terminated (access problem)
31082	Dundas/Hamilton	X	X		5	Control station- approx. 1.8 km NW of plant.
31084	Saulter St/Queen	X	X		10	Control Station- relocated to 31126 in 1986.
31126	Post Office-Eastern Ave.	X	X		11	Control station-approx. 0.8 km NE of plant.

FIGURE 4
LOCATION OF AIR MONITORING STATIONS NEAR CANADA METAL CO.



Note: 31064 terminated April 1986.

5.1.1 Hi-vol

Suspended particulates are measured by hi-vols which are equipped with motors similar to those in household vacuum cleaners. The motors, along with timers and flow controllers, are housed in heavy aluminum shelters.

Hi-vols are operated for 24-hour periods during which time approximately 2000 cubic metres of air are pumped through preweighed glass fibre filters. Particles within the size range of 0.1 - 100 µm may be collected.

The exposed filters are sent to the laboratory for reweighing to determine the amount of suspended particulate matter deposited. The loading are then divided by the air volume to give the ambient air level in micrograms per cubic metre ($\mu g/m^3$).

Lead in suspended particulates is then determined by taking a portion of the filter and analyzing by the X-ray fluorescence (XRF) method.

Wedding et al. (1977) has shown that the collection characteristics of hi-vol samplers are strongly affected by particle size, wind speed and direction, and inlet size. However, since most lead particles have been shown to have a mass median aerodynamic diameter (MMAD) in the range of 0.25 - 1.4 µm, the hi-vols should present reasonably good estimates of ambient lead concentrations. [8]

5.1.2 Dustfall

Dustfall comprises the larger particles which settle out of the air due to the influence of gravity and is measured by exposing lined open cylinders (15 cm. in diameter by 30 cm. high) for a period of 30 days. Dustfall samplers are usually mounted on Hydro poles at a height of 4-5 metres above ground.

The total deposit in the cylinder is weighed and the dustfall level is expressed in grams per square metre per 30 days (gm/m^2/30 days). Lead in dustfall is determined by taking a portion of the sample and analyzing by atomic absorption spectroscopy (AA).

5.1.3 Anemometer

In addition to the air monitoring instruments, a wind tower was also installed in 1974. It is located on the roof of Bruce Public School on Larchmount Ave., approximately 23 m above ground.

The wind monitor includes a Bendix Aerovane, whereby its movements are converted to analogue signals by a translator. The data are then stored on a data logger as well as on chart recorders.

The primary quantity needed is the hourly average wind speed and direction. A representative value may be obtained from values taken each minute, although values taken at intervals of 1-5 seconds are better.[6] At present, charts are being read for hourly wind direction (0-360 degrees) and wind speed (kilometre/hour).

5.2 AIR QUALITY DATA ANALYSIS

An overall trend analysis was performed on the multi-year data from the two major stations, 31058 and 31064. The difference between the two sites was also be examined. Wind correlation analyses was carried out to determine the contribution by Canada Metal to the overall lead concentrations.

5.2.1 Lead In Suspended Particulates

A summary of the lead in suspended particulates data from the two hi-vol stations (31058 & 31064), as well as the two control stations (31082 & 31084), is given in Table 3. Station 31064 and 31084 have since been relocated in 1986. Although the limited data from the two new locations (31045 and 31126, respectively) are not presented here, interim results have indicated a fairly low trend.

The 1974-1986 annual geometric means for the two key stations 31058 and 31064 were plotted in Figure 5. An estimation of trends was carried out using the method of least squares. The statistical analysis can be referred to in Appendix A.

As demonstrated in Figure 5, the trend line showed a dramatic decline for both stations, particularly 31058. A decrease of approximately 76% was observed for 31058 between the year 1974 and 1986, and likewise about 66% for 31064. However, the degree of variability of the two trend lines and the fact that the initial lead concentrations at 31058 were much higher than 31064 hinted that automotive lead reduction was not solely responsible for the drastic decline in ambient lead concentrations.

TABLE 3

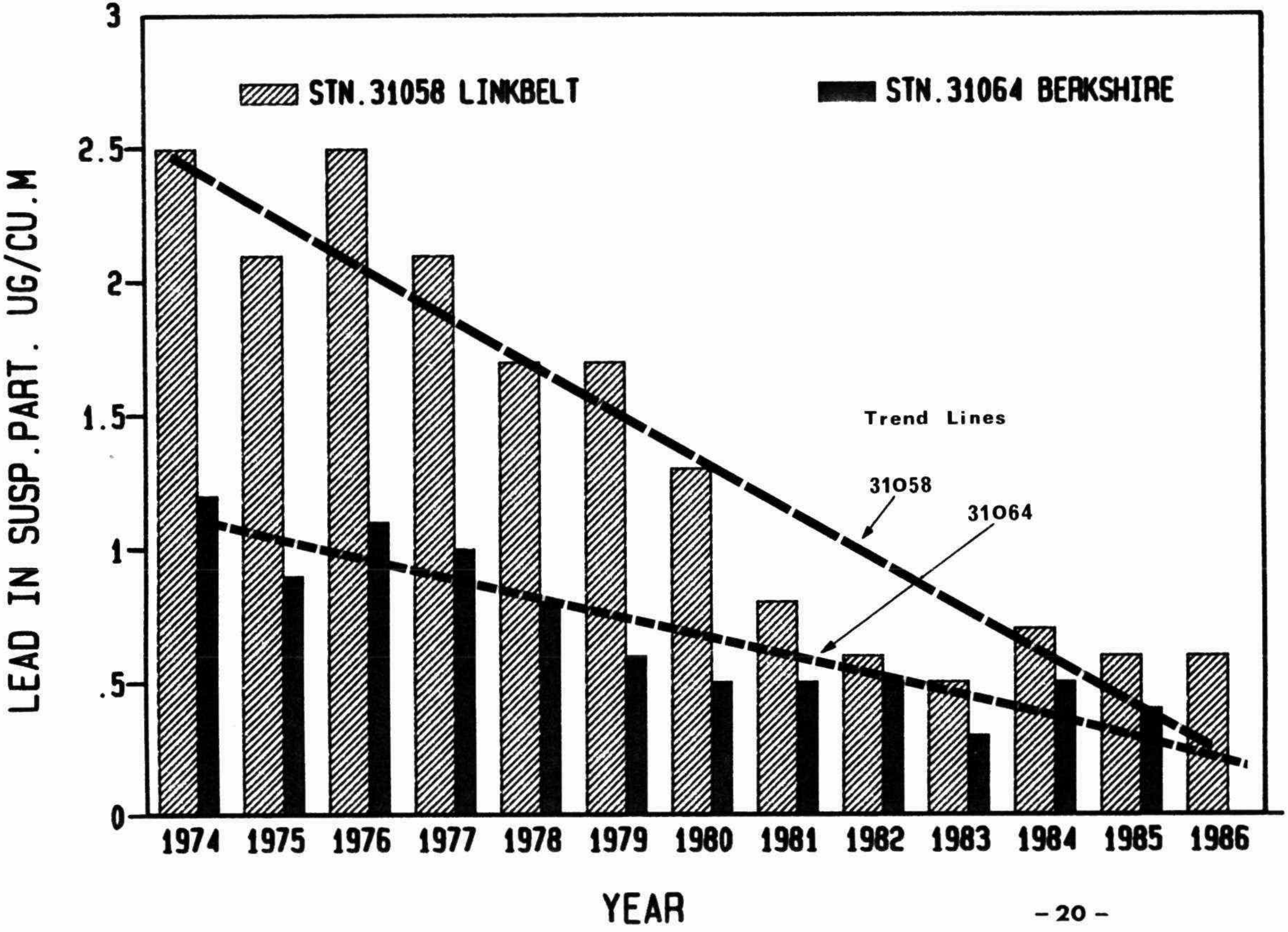
ANNUAL GEOMETRIC MEAN LEAD IN SUSPENDED PARTICULATES

NUMBER OF SAMPLES IN PARENTHESES

(UNITS: μg/m³)

Year	31058 Linkbelt	31064 Berkshire	31082 Control	31084 Control
1974	2.5(140)	1.2(194)	1.3(283)	1.0(255)
1975	2.1(224)	0.9(342)	1.1(340)	0.9(342)
1976	2.5(320)	1.1(348)	1.1(345)	0.9(351)
1977	2.1(320)	1.0(346)	1.1(325)	0.7(335)
1978	1.7(324)	0.8(311)	1.1(337)	0.8(335)
1979	1.7(337)	0.6(347)	0.8(345)	0.6(341)
1980	1.3(324)	0.5(345)	0.6(350)	0.3(345)
1981	0.8(345)	0.5(351)	0.7(349)	0.4(352)
1982	0.6(344)	0.5(253)	0.4(343)	0.3(340)
1983	0.5(350)	0.3(247)	0.4(349)	0.2(345)
1984	0.7(359)	0.5(249)	0.4(351)	0.4(346)
1985	0.6(338)	0.4(238)	0.3(335)	0.2(320)
1986	0.6(340)	0.2(80)	0.4(248)	0.2(175)

FIG. 5 LEAD IN SUSPENDED PARTICULATES (GEOMETRIC MEAN)



Ambient lead levels also drop off rapidly with distance away from the source. Although station 31064 is only about 50 metres north of Canada Metal, the annual average lead levels over the years have been significantly lower than those recorded at station 31058, which is approximately 15 metres north-east/east of the plant. As seen in Table 3, the levels at 31064 have also been comparable to those at the control stations, particularly 31082.

By using testing hypotheses, the difference between the means (1974-1986 inclusive) was confirmed to be significantly different at the 95% confidence level; that is, this deviation is too large to be accounted for by chance. The statistics on the testing between means are summarized in Appendix B.

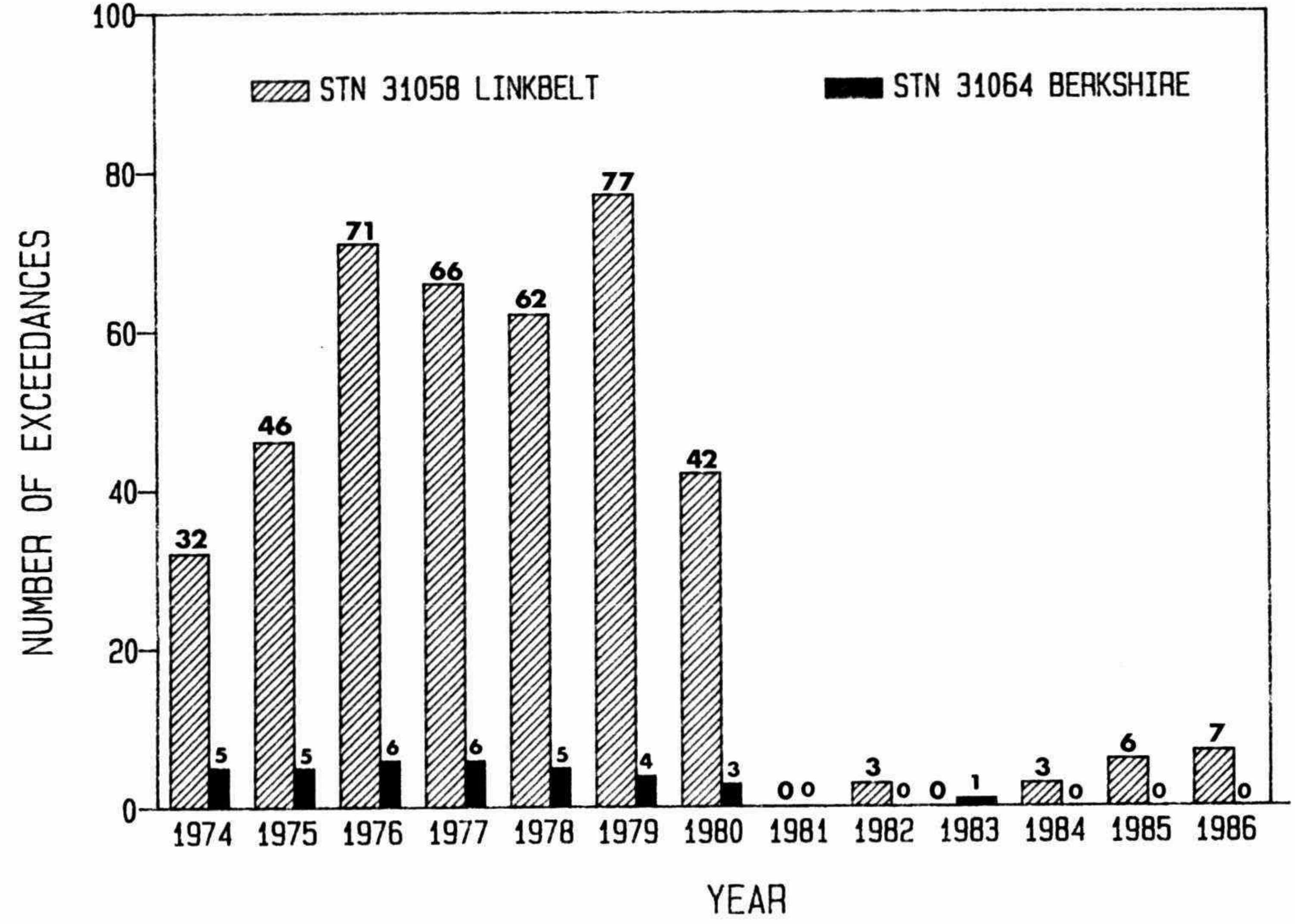
A similar test was further carried out using only 1986 data (See Appendix B). There was a very significant difference between the two sites at the 95% confidence level. This indicated that the 1986 lead concentrations detected at station 31064 remained significantly lower than those recorded at station 31058.

The annual geometric mean for 31058 over the last five years was around 0.6 $\mu g/m^3$. This dramatic decrease, as opposed to the steady decline in automotive lead emissions, reflected the effects of major abatement programs that were imposed on the company in late 1979/1980.

Not surprisingly, the number of exceedances of the Ambient Air Quality Criteria has also displayed a downward trend at both locations as shown in Figure 6. There was a slight increase at station 31058 in 1985 and 1986 mainly due to plant upsets. All exceedances have been or are under investigation by the Ministry. A summary of the exceedances between 1981 and 1986 is presented in Appendix C.

FIGURE 6

NUMBER OF EXCEEDANCES OF 24-HOUR LEAD CRITERION



5.2.2 Lead In Dustfall

The location of the dustfall stations was shown earlier in Figure 4. A summary of the 1974-1986 lead in dustfall data is given in Table 4.

Annual averages ranging from 0.008 to 0.048 gm/m^2/30 days were recorded for 1986. Data from the two new sites (31045 & 31126) were not included, but their limited results indicated fairly low values, particularly 31126. Like suspended particulate lead, lead in dustfall concentrations also drop off quickly with distance from the plant.

In general, all stations met the Ontario guideline of 0.1 gm/m^2/30days with a few exceptions. Most exceedances occurred at the closest station to the plant, 31058.

As in suspended lead, significant drops were observed for lead in dustfall levels between 1975 and 1986. Figure 7 demonstrated the decreasing trends at stations 31058 and 31064 as well as the control station 31082. The two main sites experienced an approximate 77% and 50% drop, respectively.

5.2.3 Wind Correlation

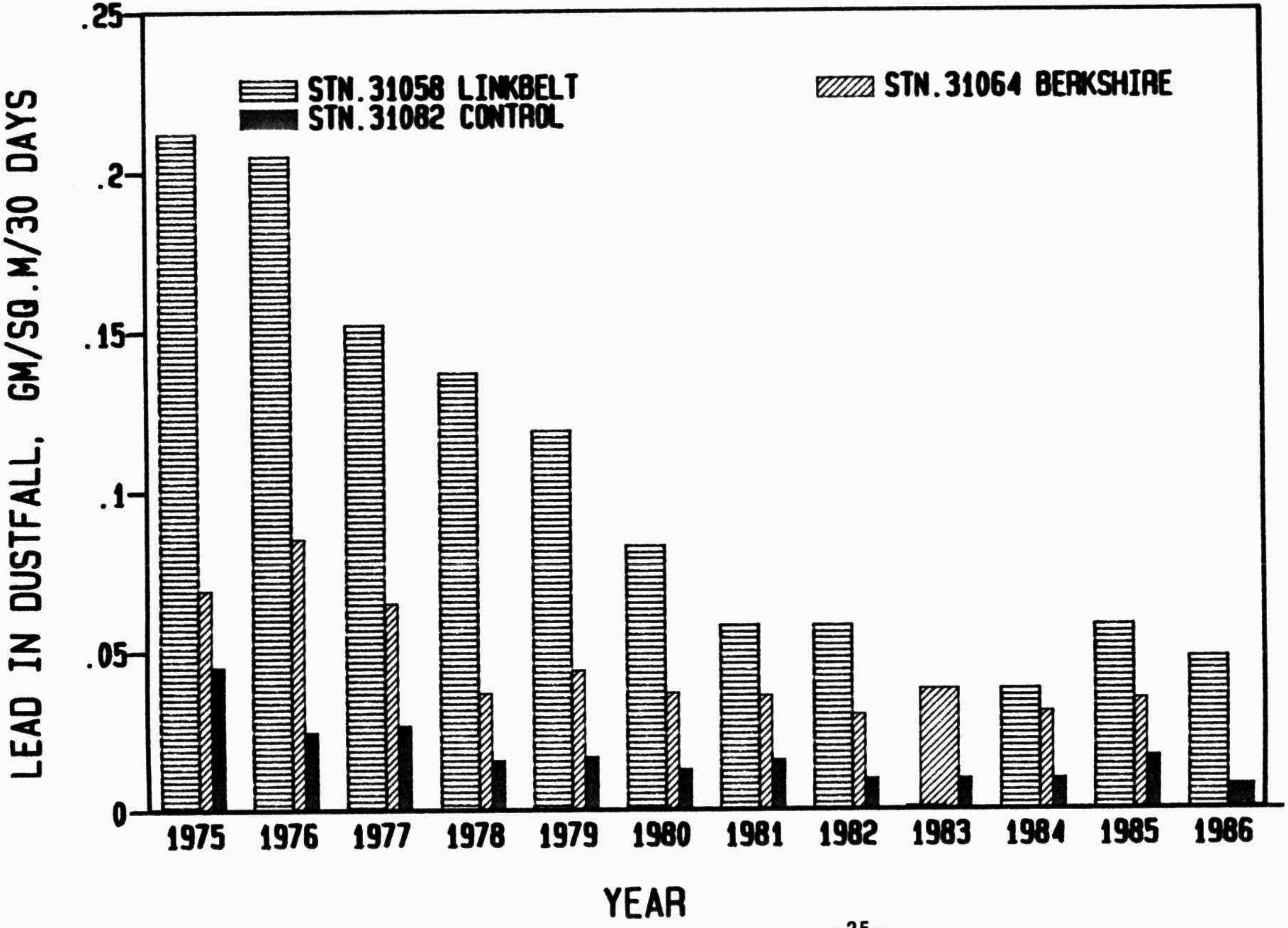
Wind correlation analyses were carried out to determine whether the suspended particulate lead levels would correlate with the number of hours during the sampling periods that winds were in the directions from the plant to the samplers. For each lead value, there were 24 corresponding wind direction measurements which were grouped into 16 sectors plus the category for calm conditions (i.e. N, NNE, NE, ENE, E, ESE, SE, SSE, S.....CALM).

TABLE 4
ANNUAL MEAN LEAD IN DUSTFALL (GM/SQ.M./30 DAYS)

YEAR	31019	31058	31059	31060	31064	31082	31084
1974	0.072	---	0.072	0.032	---	0.029	0.015
1975	0.072	0.212	0.060	0.037	0.069	0.045	0.015
1976	0.066	0.205	0.050	0.022	0.085	0.025	0.015
1977	0.071	0.152	0.050	0.018	0.065	0.027	0.011
1978	0.060	0.137	0.065	0.017	0.037	0.016	0.016
1979	0.071	0.119	0.040	0.015	0.044	0.017	0.014
1980	0.043	0.083	0.032	0.017	0.037	0.013	0.010
1981	0.042	0.058	0.028	0.017	0.036	0.016	0.009
1982	0.049	0.058	0.027	0.013	0.030	0.010	0.010
1983	0.039	(5mo.)	0.026	0.014	0.038	0.010	0.009
1984	0.047	0.038	0.028	0.013	0.031	0.010	0.008
1985	0.055	0.058	0.032	0.021	0.035	0.017	0.007
1986	0.040	0.048	0.022	0.008	Term.	0.008	Term.

*** Refer to Figure 4 (Page 15) for station locations ***

FIG.7 ANNUAL MEAN LEAD IN DUSTFALL



Since the significant drop of particulate lead occurred in 1981 and had since levelled off to a certain extent, data from the last six years (1981-1986 inclusive) were used in the correlation analyses. To assure completeness of data, wind data from the Toronto Island Airport were used in the computations.

Wind direction correlation coefficients for station 31058 and 31064 are given in Table 5. As shown in Figure 8 and 9 (to the right of the Y-axis), significant correlations were observed between lead concentrations recorded at both station 31058 & 31064 and the number of hours of wind that were in the direction from the plant complex towards the sampling sites. This indicated that although there was a dramatic decrease in lead levels, Canada Metal was the principle source of lead measured at the two locations.

There was often concern about the re-entrainment of lead. If re-entrained lead is a major factor, particulate lead levels would rise with increasing wind speeds. Similar wind correlation analyses were done using various class of wind speed against each daily lead value (i.e. 0-2, 3-4, 5-9, 10-14, 15-19, ...km/hr etc).

Correlation coefficients obtained from the wind speed analyses for both sites are given in Table 6. As shown in Figure 8 and 9 (to the left of the Y-Axis), the degree of correlation actually decreased with increasing wind speeds, indicating higher wind speeds would help the dispersal of air pollutants at both sampling sites.

TABLE 5
WIND DIRECTION - PARTICULATE LEAD CORRELATION
(JANUARY 1/1980 TO NOVEMBER 31/1986)
(SAMPLE SIZE - 1949)

WIND DIRECTION	CORRELATION COEFFICIENTS 31058	 31064
N	-0.17	-0.13
NNE	-0.15	-0.10
NE	-0.15	-0.14
ENE	-0.23	-0.16
E	-0.28	-0.08
ESE	-0.15	0.04
SE	-0.06	0.11 *
SSE	0.01	0.27
S	0.10 *	0.46
SSW	0.33	0.43
SW	0.45	0.26
WSW	0.44	0.11
W	0.26	-0.06
WNW	-0.01	-0.18
NW	-0.11	-0.18
NNW	-0.16	-0.16
CALM	0.08	0.27

Note: Wind data from Toronto Island Airport used.
Minimum no. of reading for acceptable data - 16/24.

*

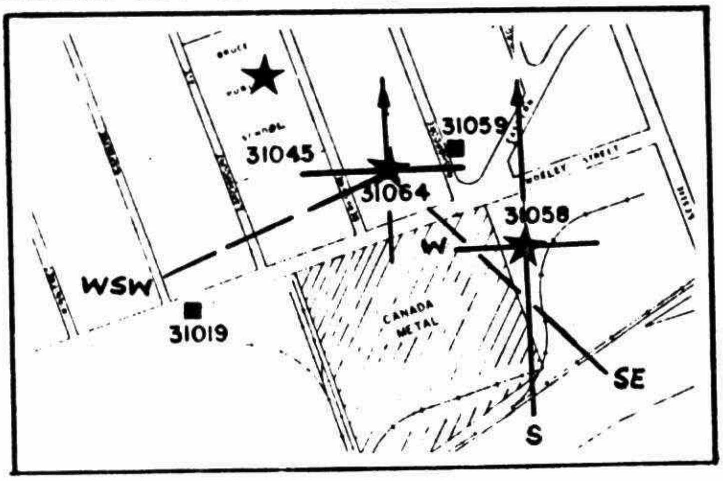
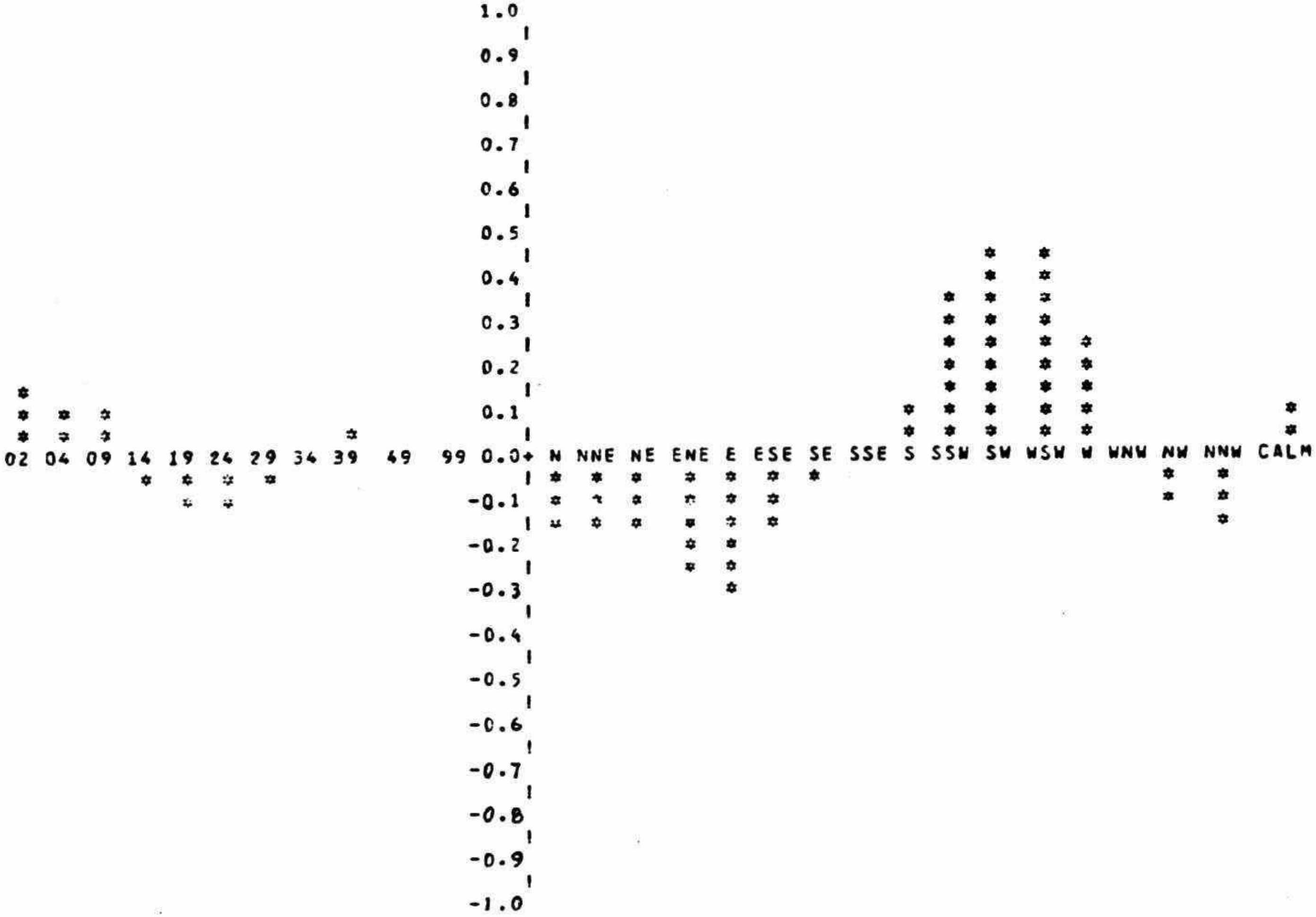
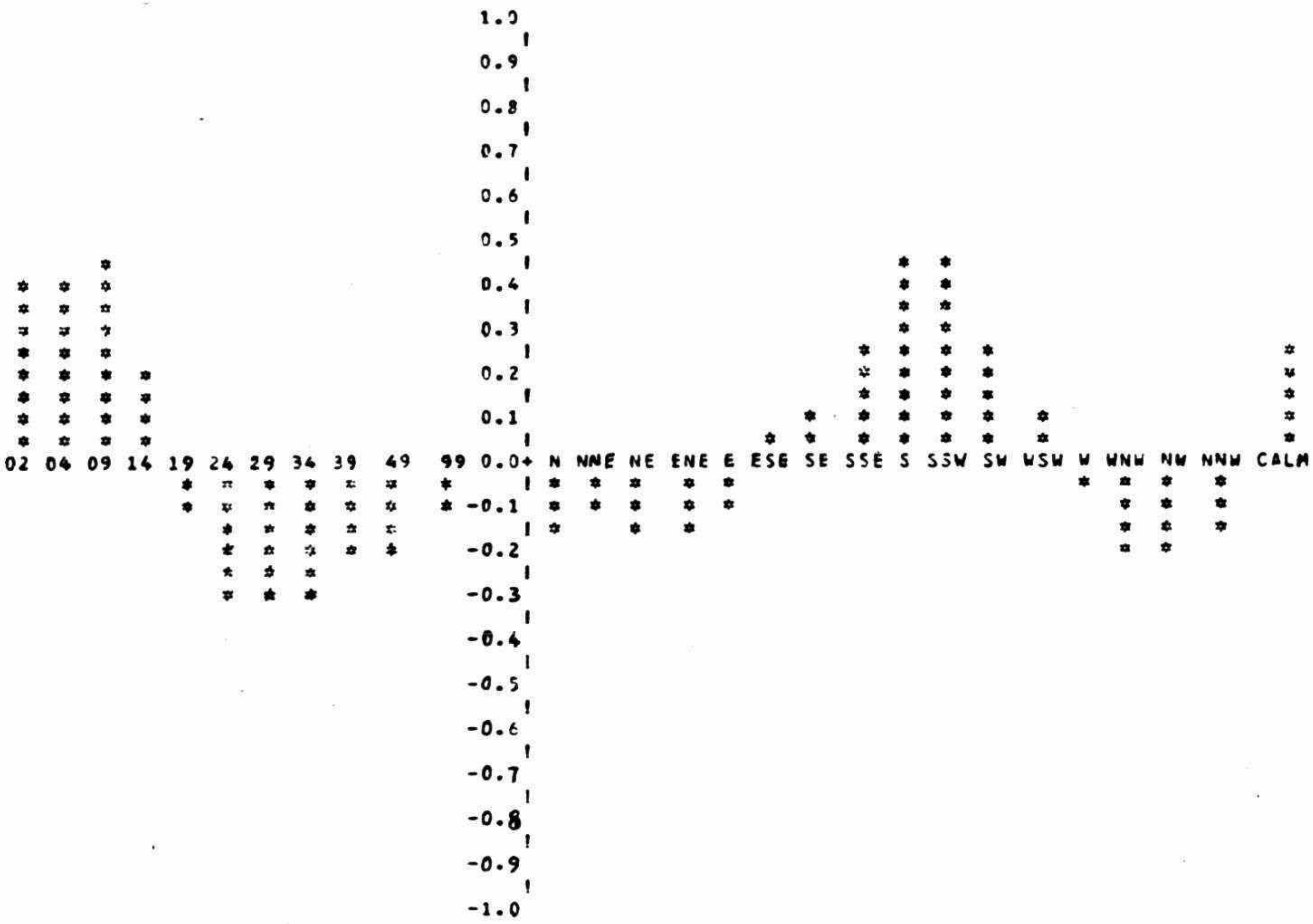


FIGURE 8
WIND - PARTICULATE LEAD CORRELATION FOR STATION 31058
(JANUARY 1/1980 TO NOVEMBER 31/1986)



Note: Wind speed values indicate upper limits for the class;
Lower limits = upper limit for previous class + 1.

FIGURE 9
WIND - PARTICULATE LEAD CORRELATION FOR STATION 31064
(JANUARY 1/1980 TO NOVEMBER 31/1986)



Note: Wind speed values indicate upper limits for the class;
Lower limits = upper limit for previous class + 1.

TABLE 6

WIND SPEED - PARTICULATE LEAD CORRELATION

(JANUARY 1/1980 TO NOVEMBER 31/1986)
(SAMPLE SIZE - 1949)

WIND SPEED KM/HR	CORRELATION COEFFICIENTS 31058	31064
00-02	0.13	0.38
03-04	0.12	0.38
05-09	0.09	0.44
10-14	-0.06	0.18
15-19	-0.12	-0.11
20-24	-0.08	-0.29
25-29	-0.04	-0.30
30-34	-0.01	-0.32
35-39	0.05	-0.22
40-49	0.01	-0.19
50-99	0.00	-0.08

Note: Wind data from Toronto Island Airport used.
Minimum no. of reading for acceptable data - 16/24.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Both lead in suspended particulates and lead in dustfall concentrations displayed a downward trend during the period 1974-1986. This reflected the effects of major abatement programs that were imposed on Canada Metal in the 1970's as well as the drastic reduction of automotive lead emissions.

Ambient lead levels also drop off rapidly with distance from the plant. The closest residential sampling site 31064 (∼50 metres N. of plant) had a 66% drop in particulate lead level while the closest station 31058 (∼15 metres NE/E of plant) had a 76% decline between the year 1974 and 1986.

Statistical tests indicated that the amount of lead detected at the residential site (31064) continued to be significantly lower than the industrial site (31058). The annual geometric mean for both locations had levelled off in the last 5 years, ranging from 0.3 to 0.7 $\mu g/m^3$.

Wind correlation analyses showed that Canada Metal remained a principal source of lead. There were occasional plant upsets which resulted in exceedances of the Ambient Air Quality Criteria.

Although a large database has been established since 1974, it is recommended that the surveillance of the company be continued as lead remains one of the major air toxics. However, any expansion of the current air monitoring network is considered neither technically nor economically justifiable.

7.0 REFERENCES

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9. U.S. Environmental Protection Agency. Environmental Lead and Public Health, No. AP-90. Air Pollution Control Office, Research Triangle Park, NC 27709. March 1971.

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8.0 APPENDIX A

STATISTICS ON TREND ANALYSIS

Trend analysis using the method of least squares:

$y' = a + bx$, where $a = \bar{y}$ and $b = \frac{\Sigma xy}{\Sigma x^2}$

By setting 1980 to be the base year, the following table can be drawn up:

			31058	31058	31058	31064	31064	31064
Year	Code		Lead			Lead		
x	x	x^2	y	xy	y'	y	xy	y'
1974	-6	36	2.5	-15	2.484	1.2	-7.2	1.105
1975	-5	25	2.1	-10.5	2.297	0.9	-4.5	1.030
1976	-4	16	2.5	-10	2.109	1.1	-4.4	0.955
1977	-3	9	2.1	- 6.3	1.922	1.0	-3.0	0.880
1978	-2	4	1.7	- 3.4	1.735	0.8	-1.6	0.804
1979	-1	1	1.7	- 1.7	1.548	0.6	-0.6	0.729
1980	0	0	1.3	0	1.362	0.5	0	0.654
1981	+1	1	0.8	+ 0.8	1.175	0.5	+0.5	0.579
1982	+2	4	0.6	+ 1.2	0.988	0.5	+1.0	0.503
1983	+3	9	0.5	+ 1.5	0.801	0.3	+0.9	0.428
1984	+4	16	0.7	+ 2.8	0.614	0.5	+2.0	0.353
1985	+5	25	0.6	+ 3.0	0.427	0.4	+2.0	0.277
1986	+6	36	0.6	+ 3.6	0.240	0.2	+1.2	0.202
n=13	Σ=0	182	17.7	-34		8.5	-13.7	

∴ For 31058, $a = 17.7/13 = 1.362$ and $b = -34/182 = -0.187$;

$y' = 1.362 - 0.187\,x$ (Trend line for 31058)

∴ For 31064, $a = 8.5/13 = 0.654$ and $b = -13.7/182 = -0.075$;

$y' = 0.654 - 0.075\,x$ (Trend Line for 31064)

APPENDIX B

STATISTICS ON TESTING HYPOTHESES

Testing between two means using the following hypotheses:

$H_o : \mu 1 - \mu 2 = 0$ (i.e. no difference)
$H1 : \mu 1 - \mu 2 \neq 0$

Using 1974-1986 geometric means from 31058 and 31064,

Average	$\overline{X1} = 1.362$	$\overline{X2} = 0.654$
Std.Dev.	$S1 = 0.772$	$S2 = 0.320$
# Years	$n1 = 13$	$n2 = 13$

$$t = \frac{\overline{x1} - \overline{x2}}{[s^2(^1/n1 + {}^1/n2)]^{0.5}}$$

$$\text{where} \quad s^2 = \frac{(n1-1)S1^2 + (n2-1)S2^2}{n1 + n2 - 2} \quad = 0.349$$

$$\therefore t = \frac{1.362 - 0.654}{[0.349\ (^1/13 + {}^1/13)]^{0.5}} \quad = 3.055 \leftarrow\leftarrow\leftarrow$$

Critical Value for t at 95% confidence level is ±2.064 (Degree of freedom = n1+n2-2 = 24); thus t is outside acceptance range, →→→ reject Ho; i.e. there is a significant difference between the two means.

Similarly for 1986 raw data only:

1986 mean	$\overline{X1} = 0.6$	$\overline{X2} = 0.2$
Std. Dev.	$S1 = 0.298$	$S2 = 0.225$
# Obs.	$n1 = 311$	$n2 = 80$

Since sample size is larger than 30, use z instead of t:

$$\text{and } z = \frac{\overline{X1} - \overline{X2}}{[\ S1^2/n1 + S2^2/n2\ ]^{0.5}} \quad = 13.2 \leftarrow\leftarrow\leftarrow$$

Critical Value for z at 95% confidence level is ±1.96; thus z is way outside acceptance range, →→→ reject Ho; i.e. there is a very significant difference between the two means.

APPENDIX C

SUMMARY OF CRITERIA EXCEEDANCES

NUMBER OF EXCEEDANCES OF THE 24-HOUR LEAD CRITERIA OF 5 µg/m³ (1981-1986)

Station	Year	No.of Samples	No.of Exceedance	% Exceedance	Date	Lead µg/m³
31058	1981	345	0	0	N/A	N/A
	1982	344	3	0.9	Feb.26 Mar.1 Aug.19	8.7 5.2 6.1
	1983	350	0	0	N/A	N/A
	1984	350	3	0.9	Feb.22 May 30 Nov.22	5.8 9.0 5.4
	1985	338	6	1.8	Feb.28 May 10 May 31 Aug.23 Sep.20 Oct.9	11.6 10.5 9.4 7.0 5.5 7.8
	1986	340	7	2.6	Mar.21 Mar.25 Mar.26 Apr.29 Jun.16 Jul.6 Dec.22	6.2 5.3 12.7 7.1 5.2 5.6 5.4
31064	1981	351	0	0	N/A	N/A
	1982	253	0	0	N/A	N/A
	1983	247	1	0.4	Jun.13	6.7
	1984	249	0	0	N/A	N/A
	1985	238	0	0	N/A	N/A
	1986	80	0	0	N/A	N/A

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